Composition and Geographic Distribution of Mangrove Macroalgal Communities in New South Wales

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This study of the algae associated with the pneumatophores of mangrove communities on the New South Wales coast records the presence of 32 taxa of macroalgae, including 15 Rhodophyta, 6 Phaeophyta, and 11 Chlorophyta. Relevant morphosystematic and distributional data are included for each species. There are twenty-two new records for the mangrove communities of NSW, but only a few of these are new records for the State: *Bostrychia kelanensis, Caloglossa adnata*, and *Striaria attenuata*. The most frequently occurring algae were those of the *Bostrychia – Caloglossa* association, with *Caloglossa leprieurii* the most frequent, and *Catenella nipae* the most widespread. Comparison of the New South Wales mangrove algal flora with the floras of mangrove communities elsewhere in eastern and southern Australia indicates that it shows greatest similarity in both total number of species, and shared species, with that of southern Queensland. There are several species of tropical or subtropical affinity: *Bostrychia flagellifera, B. kelanensis* and *Caloglossa adnata.*

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INTRODUCTION

With few exceptions data on algae associated with Australian mangrove communities have been collected only as an adjunct to works dealing with the phanerogamic vegetation. The major exceptions are the studies on the composition and geographic distribution of mangrove algae in Victoria (Davey and Woelkerling, 1980) and in the Spencer Gulf, South Australia (Beanland and Woelkerling, 1982, 1983). For localities on the eastern seaboard there is a species list and a brief site description for Moreton Bay, SE Queensland (Cribb, 1979), and a limited account for the lower Hunter River in New South Wales (Cheng, 1983). King (1981b, c) has described in detail some aspects of the algal communities of Botany Bay, Sydney.

King (1981a) and Saenger *et al.* (1977) provided general species lists which summarized earlier Australian data and included newer records. In the former it was not clear which were additions to previously published records, nor which were in mangrove communities, salt marshes or both. Post (1936 *et seq.*) included numerous records of Australian mangrove zone algae in her series of papers on the distribution of the 'Bostrychietum', and specifically in her description of the Bostrychietum from Wilsons Promontory, Victoria and the Minnamurra River, New South Wales (Post, 1964).

The New South Wales coast, running as it does essentially along a line of longitude, provides an ideal opportunity to study the transition from temperate to tropical environments. Within the mangroves themselves the differences are marked, with six mangrove species in northern NSW and only two, *Avicennia marina* and *Aegiceras corniculatum*, extending to the south coast. This paper presents the results of a broad scale survey of the floristic composition of mangrove algal communities at 20 sites distributed along the entire New South Wales coast from Tweed Heads in the north to Pambula in the south. The frequency of species occurring on mangrove pneumatophores is also given. The New South Wales mangrove algal flora is compared with those of the algal

communities associated with mangroves in temperate Australia, and the relationship with the lesser known tropical Australian flora is discussed.

Materials and Method

Community composition and frequency data were collected from 20 sites on the NSW coast. At all but three localities (Mill Creek, Cattai Creek on the lower Manning River, and Sussex Inlet), two transects were run normal to the shore, and the five pneumatophores closest to the midpoint of each quarter of the transect length were collected (see Table 1 for details of transect length). A listing of all algae on the forty pneumatophores formed the basis for the analysis of frequency. At Mill Creek two transects were made, one at the head and the other at the mouth of the creek; at the lower Manning River site the transect extended across the shallow arm of the river (a full collection was made at Harrington only 10km distant); and at Sussex Inlet there was such a dearth of algal material that 100 pneumatophores from 5 transects were examined. In addition to the transect data a general collection of algae was made. Pneumatophores which appeared to support algae not found during the transect sampling were collected as well as algae growing directly on the mud or any solid substratum (wood, rock, rubbish).

The material was examined in fresh condition. All algae were carefully scraped from the pneumatophores with a sharp razor blade and washed on a cheese-cloth gauze to remove mud, and to separate the debris. Microscopic algae (Bacillariophyta and cyanobacteria) were not included in the data compilation. Voucher specimens have been deposited in the John T. Waterhouse Herbarium in the School of Botany, University of New South Wales (UNSW).

Frequency data for each species at each locality were calculated using the same formula as in Beanland and Woelkerling (1982).

$F = \Sigma N/N \times 100$ where

F = the percentage frequency; ΣN = the number of pneumatophores on which a particular alga occurred; and N = the total number of pneumatophores surveyed.

For ease of comparison with published data from southern Australia the 'relative profusion of taxa' was determined from the percentage frequency data, on the same basis as used by Woelkerling and his co-workers. Species have been assigned to one of 5 categories: Rare ($F < 5\%$); Sporadic ($F = 5\text{-}24\%$); Occasional ($F = 25\text{-}49\%$); Common ($F = 50\text{-}75\%$); Abundant ($F > 75\%$).

Results

Community composition

A total of 32 taxa of macroalgae (15 Rhodophyta, 6 Phaeophyta, and 11 Chlorophyta) were recorded in this study of the mangrove communities of New South Wales. This includes species on pneumatophores for which frequency data were calculated, as well as algae growing directly on the mud or other substrata. The localities at which these species occurred are given in Table 1. The genera are listed alphabetically within each Division and the following information is given: (i) selected references which are of taxonomic significance, in which the species is figured, or which refer specifically to Australian material; (ii) type locality; (iii) reported world wide distribution; (iv) specimens examined; (v) general remarks including distribution in Australia; as well as relevant morphological or taxonomic data.

Microalgae and cyanobacteria were common at all localities, but only occasionally were cyanobacteria in sufficient quantities to be conspicuous. *Scytonema* (*S. crispum* (C. Agardh) Born. — see Geitler, 1932: 748, fig. 477) occurred as dense tufts completely covering mangrove pneumatophores in a water-logged area of the mangal at Stuarts

TABLE 1

Location of collecting sites on the New South Wales coast

Location	Latitude	Date	Salinity	Transect length and orientation	Mangrove species present
Tweed Heads Ukerebagh Island	28°10'S	Aug. '83	14%	150m: 300°	Ac[1](UNSW 15157); Am; Bg (15156); Ht (15155); Rs (15159)
Hastings Point	28°22'	Aug. '83	14	40m: 40°	Ac (15162); Am (15161); Rs (15160)
Ballina North Arm	28°52'	Aug. '83	24	40m: 90°	Ac; Am; Bg (15169); Ea (15170); Ht
Stuarts Point	30°49'	Aug. '83	23	160m: 105°	Ac; Am
Port Macquarie Settlement Point	31°27'	Aug. '83	36	80m: 90°	Ac; Am; Ea (15174)
Harrington	31°52'	Aug. '83	24	40m: 90°	Ac; Am
Cattai Ck (lower Manning River)	31°52'	Aug. '83	18	70m: 0°	Ac; Am
Tuncurry North Arm, Wallis Lake	32°11'	Sept. '83	33	28m: 125°	Ac; Am
Port Stephens (near Nelson Bay)	32°44'	Sept. '83	34	80m: 18°	Am
Fullerton Cove (2km north of Stockton Bridge)	32°52'	Sept. '83	29	50m: 115°	Ac; Am
Careel Bay	33°37'	Sept. '83	22	160m: 135°	Ac; Am
Middle Cove (Roseville Bridge)	33°49'	Sept. '83	39	200m: 125°	Am
Weeney Bay (Botany Bay)	34°02'	Sept. '83	36	360m: 90°	Ac; Am
Mill Ck (off Georges R.)	34°00'				
mouth		June '83	2	80m: normal to	Ac; Am
head		June '83	0	6m: Creek	Ac; Am

1. Ac = *Aegiceras corniculatum* (L.) Blanco; Am = *Avicennia marina* (Forsk.) Vierh.; Bg = *Bruguiera gymnorhiza* (L.) Lamk; Ht = *Hibiscus tiliaceus* L.; Rs = *Rhizophora stylosa* Griff.; Ea = *Excoecaria agallocha* L.

TABLE 1 (concluded)

Location	Latitude	Date	Salinity	Transect length and orientation	Mangrove species present
Georges Hall Georges R.	33°58′	Sept. '83	2	4m:	Am
Minnamurra River	34°38′	Sept. '83	34	100m: 270°	Ac; Am
Sussex Inlet	35°09′	July '83	34	230m: 108°	Ac; Am
Batemans Bay Cullendulla Ck	35°44′	Sept. '83	36	48m: 320°	Ac; Am
Bermagui	36°25′	Sept. '83	36	40m: 200°	Am
Pambula	36°56′	Sept. '83	34	28m: 90°	Am

1. Ac = *Aegiceras corniculatum* (L.) Blanco; Am = *Avicennia marina* (Forsk.) Vierh.; Bg = *Bruguiera gymnorhiza* (L.) Lamk; Ht = *Hibiscus tiliaceus* L.; Rs = *Rhizophora stylosa* Griff.; Ea = *Excoecaria agallocha* L.

Point (UNSW 15033) and although it was otherwise widely distributed it was not common. *Lyngbya*, or a related genus in the Oscillatoriaceae, and a member of the Stigonematales (?*Brachytrichia balani* (Lloyd) Born. *et* Fl. — see Geitler, 1932: 553, fig. 347) were also widely distributed.

Division RHODOPHYTA

Genus *Bostrychia* Montagne 1842

Bostrychia flagellifera Post 1936: 34
References: May, 1965: 377; Post, 1961: 101, fig. 1,2(I,II)
Type locality: Parramatta R., Sydney
Reported distribution: east coast of Australia, New Zealand and Japan
Specimens examined: UNSW 13890 (lower Manning R.), 14177 (Sussex Inlet), 14188 (Mill Ck mouth), 15001 (Stuarts Point), 15011 (Tweed Heads), 15022 (Ballina), 15037 (Port Macquarie), 15050 (Careel Bay), 15066 (Fullerton Cove), 15095 (Middle Cove), 15228 (Nelson Lagoon), 15253 (Bonna Point), 15323 (Weeney Bay), 17085 (Minnamurra R.)
Remarks: B. flagellifera was locally abundant on pneumatophores in both sun-exposed and shaded positions. It also occurred on sand or mud around the bases of salt marsh plants (*Sarcocornia quinqueflora, Juncus kraussii* and *Suaeda australis*). This species has been recorded in Queensland by Saenger *et al.* (1977) and Cribb (1979). On the NSW coast it was abundant in mangroves north of Sydney. Its distribution is now extended to Nelson Lagoon (just north of Tathra) in southern NSW. It has never been recorded in Victoria or South Australia.

Bostrychia intricata (Bory) Montagne 1852: 317
References: May, 1965: 377; Tseng, 1943: 174, pl. 1, figs 4-5; Harvey, 1860: pl. 176A (incorrectly as 276A in index) as *B. mixta* Hooker and Harvey; Kumano, 1979: 15 figs 3, 12-15 as *B. mixta*; Post, 1963: 94, fig. 6 as *B. mixta*
Synonym: B. mixta Hooker and Harvey
Type locality: Falkland Islands (Islas Malvinas)
Reported distribution: Widespread in subantarctic regions and in warmer waters
Specimens examined: UNSW 15024 (Ballina), 15034 (Stuarts Point), 15241 (Pambula)
Remarks: This species is apparently common in the eulittoral of sheltered rocky shores of NSW. It has been recorded for Queensland by Saenger *et al.* (1977) and Cribb (1979), on littoral zone mud surfaces in Victoria (Davey and Woelkerling, 1980) and at Kangaroo Island, South Australia (Womersley, 1950; Post, 1963), and in Tasmania (Harvey, 1860; Cribb, 1954). It was not recorded in Spencer Gulf, South Australia (Beanland and Woelkerling, 1982).

Bostrychia kelanensis Grunow ex Post 1936: 20
References: Kumano, 1979: 18, figs 33-37; May, 1965: 377; Post, 1936: 20-22: 1968a: 81-150; Tseng, 1943: 169-171
Type locality: Kelana, New Guinea
Reported distribution: Tropical waters of the Indo-Pacific region
Specimens examined: UNSW 15012 (Tweed Heads)
Remarks: This is the only record of this species for NSW though it has been recorded for the Brisbane River (Post, 1968a). It is a predominantly tropical species and has been reported from a number of other Queensland localities (Saenger *et al.*, 1977; Cribb, 1979; Ngan and Price, 1980).

Bostrychia moritziana (Sonder) J. Agardh 1863: 862
References: Kumano, 1979: 20, figs 51-59; May, 1965: 376; Post, 1936: 10; 1963: 57
Type locality: French Guiana
Reported distribution: Widespread in tropical and temperate seas
Specimens examined: UNSW 13879, 14192 (Mill Ck head), 13888 (Harrington), 14170, 15211 (Georges Hall), 14182 (Sussex Inlet), 15025 (Ballina), 15041, 15042 (Port Macquarie), 15051 (Careel Bay), 15061, 15068 (Port Stephens), 15079 (Fullerton Cove), 15254 (Bonna Point), 15322 (Weeney Bay), 17086 (Stuarts Point)
Remarks: B. moritziana was recorded for all localities except Hastings Point and Batemans Bay. It was widespread on mangrove pneumatophores generally intermixed with other species of *Bostrychia* and *Caloglossa*. This species was abundant in Victoria (Davey and Woelkerling, 1980) and South Australia (Beanland and Woelkerling, 1982), and was also recorded for Queensland (Saenger *et al.*, 1977; Cribb 1979).

Bostrychia simpliciuscula Harvey ex J. Agardh 1863: 854
References: May, 1965: 376; Tseng, 1943: 173, pl. II, figs 6-7; Harvey, 1860: pl. 176B (incorrectly as pl. 276B in index); Post, 1936: 22 as *B. tenuis* (Harvey) Post; 1963:66 as *B. tenuis*
Synonym: B. tenuis Post
Type locality: Friendly Islands
Reported distribution: Widespread in the southern hemisphere in temperate waters
Specimens examined: UNSW 14179, 14181 (Sussex Inlet), 14187 (Weeney Bay), 14190 (Mill Ck mouth), 15006 (Stuarts Point), 15013 (Tweed Heads), 15023 (Ballina), 15030 (Hastings Point), 15078 (Fullerton Cove), 15087 (Middle Cove), 15213 (Bermagui), 15223, 15224, 15249 (Minnamurra R.), 15227 (Nelson Lagoon), 15225 (Bonna Point)
Remarks: This species has been recorded for southern Australia (Womersley, 1950; Post, 1936, 1963 and 1964) including Tasmania (Cribb, 1954) but was not recorded for Victoria by Davey and Woelkerling (1980) nor Spencer Gulf, South Australia (Beanland and Woelkerling, 1982). However in these latter studies the tropical species *B. radicans* was recorded as the most abundant and widespread alga. The relationship between *B. radicans* and *B. simpliciuscula* requires further investigation.

Genus *Caloglossa* J. Agardh 1876

Caloglossa adnata (Zanardini) De Toni
References: May, 1965: 385; Post, 1936: 47, fig. 1; 1955: pl. 4; 1963: 99
Type locality: Kuching, Borneo, East Malaysia
Reported distribution: Widespread in tropical waters
Specimen examined: UNSW 15020 (Ballina)
Remarks: This species has been recorded for Queensland, the southern-most records being for Brisbane River (Post, 1963) and Moreton Bay (Cribb, 1979). The record for Ballina (28° 52'S) extends the known range of the species south into NSW. Within the mangal it was found only in densely shaded regions and grew on pneumatophores, mangrove tree bases and rock surfaces.

Caloglossa leprieurii (Montagne) J. Agardh 1876: 499
References: May, 1965: 395; King, 1981a: fig. 12.7C,D; Papenfuss, 1961: figs 1-30; Post, 1936: 40; 1963: 99
Type locality: Cayenne, French Guiana
Reported distribution: Widespread in tropical and temperate seas
Specimens examined: UNSW 13881 (Mill Ck mouth), 13883 (Mill Ck head), 13886 (Harrington), 13891 (lower Manning R.), 13895 (Stuarts Point), 14168 (Liverpool), 14169

(Deepwater Park), 14180 (Sussex Inlet), 14184, 15256 (Weeney Bay), 15008 (Tweed Heads), 15021 (Ballina), 15031 (Hastings Point), 15036 (Port Macquarie), 15047 (Careel Bay), 15063 (Port Stephens), 15065 (Fullerton Cove), 15086 (Tuncurry), 15209 (Georges Hall), 15215, 15216 (Bermagui), 15221 (Minnamurra R.), 15244 (Pambula), 15263 (Quibray Bay), 15264 (Bonna Point)

Remarks: C. leprieurii occurred at all sites on the NSW coast except Batemans Bay. It occurred widely throughout the mangal in both shaded and sun-exposed areas. It may occur as the sole alga on pneumatophores but was more often mixed with other species of the *'Bostrychia-Caloglossa* Association'. It is otherwise widely distributed in mangrove communities in southern Australia (Davey and Woelkerling, 1980; Beanland and Woelkerling, 1982) and also in north-eastern Australia (Saenger *et al.*, 1977; Cribb, 1979).

Caloglossa ogasawaraensis Okamura

References: Post, 1936: 60; 1963: 104; 1966: 317, fig. 3; 1967: 263, figs 5,6; 1968: 279, fig. 10

Synonym: C. bombayensis Boergesen

Type locality: Bonin Islands (Ogasawara-jima), Japan

Reported distribution: Widely distributed in tropical waters

Specimens examined: UNSW 13885 (Harrington), 14171 (Deepwater Park), 14185 (Weeney Bay), 15016 (Tweed Heads), 15026 (Ballina), 15027 (Hastings Point), 15043 (Port Macquarie), 15052 (Careel Bay), 15077 (Port Stephens), 15089 (Middle Cove), 15205 (Georges Hall)

Remarks: C. ogasawaraensis was recorded for Queensland (Saenger *et al.*, 1977; Cribb, 1979). It was recorded in NSW from earlier records of the Parramatta River (Post, 1936), and as *C. bonayensis* (Post 1961). At Careel Bay (salinity 22°/oo) it was locally abundant on pneumatophores at the seaward edge of the mangal. At Georges Hall, Georges R., (salinity 2°/oo) it was abundant and often the only conspicuous alga on the pneumatophores and rocks.

Genus *Catenella* Greville 1830

Catenella nipae Zanardini 1872: 143

References: King, 1981a: fig. 12.7B; May, 1965: 360; Min-Thein and Womersley, 1976: figs 17, 56; Post, 1936: 68; 1963: 116, fig. 8; 1964: 251; Tseng, 1942: 143, fig. 2

Type locality: Sarawak, Borneo

Reported distribution: India, south-east Asia, Australia and New Zealand

Specimens examined: UNSW 13878 (Mill Ck, midway between head and mouth), 13880, 13882 (Mill Ck head), 13887 (Harrington), 13893 (lower Manning R.), 13894 (Stuarts Point), 14178 (Sussex Inlet), 14190 (Mill Ck mouth), 15010 (Tweed Heads), 15019 (Ballina), 15028 (Hastings Point), 15035 (Port Macquarie), 15053 (Careel Bay), 15062 (Port Stephens), 15064 (Fullerton Cove), 15094 (Middle Cove), 15214 (Bermagui), 15225 (Minnamurra R.), 15229 (Nelson Lagoon), 15242 (Pambula), 15258 (Spit Bridge), 15259 (Weeney Bay), 15260, 15262 (Bonna Point), 15261 (Quibray Bay)

Remarks: C. nipae was widely distributed in Victoria (Davey and Woelkerling 1980) but was not recorded for Spencer Gulf, South Australia (Beanland and Woelkerling, 1982). In NSW it was recorded at all sites except the hyposaline locality at Georges Hall. It occurs predominantly on pneumatophores and the bases of the mangrove trees especially in shaded areas where it may be the only conspicuous alga. It is also recorded for Queensland (Saenger *et al.*, 1977; Cribb, 1979).

Genus *Centroceras* Kuetzing 1841

Centroceras clavulatum (C. Agardh) Montagne 1846: 140
References: Abbott and Hollenberg, 1976: 604, fig. 547; May, 1965: 371
Type locality: Caloa, Peru
Reported distribution: Widely distributed in temperate and tropical waters
Specimen examined: UNSW 15073 (Port Stephens)
Remarks: C. clavulatum was recorded in the mangals of Spencer Gulf, South Australia (Beanland and Woelkerling, 1982) and Victoria (Davey and Woelkerling, 1980). Cribb (1979) recorded it for Moreton Bay, Queensland. In this survey it was recorded at only one locality, Port Stephens, where small plants occurred mixed with species of *Bostrychia* and *Caloglossa* on pneumatophores.

Genus *Chondria* C. Agardh 1817

Chondria sp.
Specimen examined: UNSW 15067 (Port Stephens)
Remarks: This species was recorded at only one locality, Port Stephens. It was common in the mid to lower portion of the mangrove zone. The large (*c.* 10cm long) plants were attached to the bases of the pneumatophores and spread over the mud surface. The infertile plants appear to belong to an as yet undescribed species which also occurs in southern Australia (E. Gordon-Mills, pers. comm.).

Genus *Erythrotrichia* J. Agardh

Erythrotrichia carnea (Dillwyn) J. Agardh 1883: 15
References: Abbott and Hollenberg, 1976: 286, fig. 228; Chapman, 1969: 11, fig. 4; Kornmann and Sahling, 1978: 258, pl. 148A-C; Levring, 1953: 462; May, 1965: 354
Type locality: Wales
Remarks: E. carnea was recorded at Ballina only, but the species is cosmopolitan. It was recorded for mangrove areas in South Australia (Beanland and Woelkerling, 1982) though at only one locality. The small size of the plant may cause it to be overlooked in a broad vegetation survey.

Genus *Gracilaria* Greville

Gracilaria verrucosa (Hudson) Papenfuss 1950: 195
References: May, 1948: 18, figs 1-2, pls 1(1,2), 2(1) as *G. confervoides* (Linnaeus) Greville
Synonym: G. confervoides (Linnaeus) Greville
Type locality: England
Reported distribution: Widely distributed in temperate and tropical waters
Specimens examined: UNSW 15014 (Tweed Heads), 15017 (Ballina), 15038 (Port Macquarie), 15056 (Careel Bay), 15091 (Middle Cove).
Remarks: G. verrucosa was recorded in mangrove swamps in NSW and Queensland, as *G. confervoides*, in Saenger *et al.* (1977). In this survey *G. verrucosa* was common in most sites north of Sydney but on the south coast was recorded only at Pambula. The plants spread out on the mud surface and are, at least initially, attached to pneumatophores or small shell fragments in the mud. Since only algae growing attached to pneumatophores were scored for frequency *Gracilaria verrucosa* is under-represented in the data. The older plants are often apparently unattached and therefore comparable to the free-living *Gracilaria secundata* f. *pseudoflagellifera* communities reported for New Zealand (Chapman, 1975).

Genus *Polysiphonia* Greville

Polysiphonia ?scopularum Harvey
Reference: Womersley, 1979: 467-469, fig. 2A-E
Type locality: Rottnest Island, Western Australia
Reported distribution: Southern Australia and Queensland, otherwise widespread
Specimens examined: UNSW 15054 (Careel Bay), 15075 (Port Stephens), 15081 (Tuncurry), 15090 (Middle Cove)
Remarks: Sterile plants of *Polysiphonia ?scopularum* were recorded for a few localities. The species has been recorded from mangroves in Spencer Gulf, South Australia (Beanland and Womersley, 1982) and for Queensland (Cribb, 1979).

Genus *Spyridia* Harvey 1833

Spyridia filamentosa (Wulfen) Harvey 1833: 336
References: Abbott and Hollenberg, 1976: 608; Womersley and Cartledge, 1975: fig. 1; May, 1965: 369 as *S. breviarticulata* J. Agardh
Type locality: Adriatic Sea
Reported distribution: Widely distributed in tropical and subtropical waters. All around the Australian coast
Specimens examined: 15076 (Port Stephens), 15080 (Tuncurry), 15257 (Quibray Bay)
Remarks: S. filamentosa was recorded at only four localities. In Careel Bay and Botany Bay it was common in the lower regions of the mangal in the late summer and autumn, but not in spring. It may not have been recorded from other localities as a result of its seasonal nature. It was recorded in the mangals of Spencer Gulf, South Australia (Beanland and Woelkerling, 1982) and was also reported for Queensland (Saenger *et al.*, 1977, Cribb, 1979).

Division PHAEOPHYTA

Genus *Acinetospora* Bornet 1891

Acinetospora crinita (Carmichael ex Harvey) Kornmann 1953: 205, figs 1-14
Reference: Kornmann and Sahling, 1978: fig. 60(A-H)
Type locality: Appin, Scotland
Reported distribution: Common in temperate seas
Specimen examined: UNSW 15055 (Careel Bay)
Remarks: In Australia *A. crinita* has been recorded on rocky coasts (Clayton, 1974). In this survey it was recorded only at Careel Bay where it formed tangled tufts amongst pneumatophores at the seaward edge of the mangrove vegetation.

Genus *Asperococcus* Lamouroux

Asperococcus bullosus (Lamouroux) De Toni 1895: 493
Reference: Borowitzka *et al.*, 1982: 22, fig. 9
Type locality: 'Medit. Gall'
Reported distribution: Widespread
Specimens examined: UNSW 13844 (Botany Bay), 15057 (Port Stephens), 15218 (Bermagui)
Remarks: A. bullosus was recorded in estuaries in southern Australia and north to Pittwater (Borowitzka *et al.*, 1982). This survey extends the recorded range of this species north to Port Macquarie. Initially the species grows as an epiphyte on *Posidonia* and cast plants continue to grow in the mangrove swamps.

Genus *Ectocarpus* Lyngbye 1819

Ectocarpus siliculosus (Dillwyn) Lyngbye 1819: 131
Reference: Kornmann and Sahling, 1978: 94, fig. 45(B,C)
Type locality: Europe
Reported distribution: Cosmopolitan
Specimens examined: UNSW 15004 (Stuarts Point), 15206 (Georges Hall), 15217 (Bermagui), 15233 (Batemans Bay), 15245 (Pambula)
Remarks: This species has been recorded for mangroves in South Australia (Beanland and Woelkerling, 1982), Victoria (Davey and Woelkerling, 1980) and Queensland (Cribb, 1979). In this survey fertile *E. siliculosus*, with very long spine-like plurilocular sporangia (some subtending hair-like filaments), was recorded at five localities. It occurred draped over pneumatophores at the seaward edge of the mangal and also extended into the sublittoral as an epiphyte on *Zostera.*

Genus *Hormosira* (Endlicher) Meneghini 1838

Hormosira banksii (Turner) Decaisne 1842: 331
References: Borowitzka *et al.*, 1982: 43, fig. 25B; Clarke and Womersley, 1981: 497, fig. 1A; King, 1981a: 325, fig. 12.9(A,B); 1981b: 569, figs 3 & 9; 1981c: 107
Type locality: 'Novae Hollandae'
Reported distribution: Widespread in temperate Australasia
Specimens examined: UNSW 13708 (Weeney Bay), 15212 (Bermagui), 15240 (Pambula)
Remarks: King (1981a,b,c) provided details on the extensive unattached *H. banksii* communities in southern Botany Bay. Such well developed free-floating communities have not been found at other localities, although a community covering over 200m of shore is present in Carama Ck, which runs into Hare Bay in northern Jervis Bay. Populations of *H. banksii* on the southern NSW coast (Narooma, Bermagui and Pambula) are not of the same form as that in Botany Bay and are initially attached to pneumatophores at the lower levels of the mangroves. The plants attain a large size (up to approximately 50cm in length) but in contrast to the attached populations of *H. banksii* growing in hypersaline waters with *Avicennia* at Booti Is., Wallis Lake (King, 1981b: fig. 9), they are much branched.

Genus *Sphacelaria* Lyngbye 1819

Sphacelaria sp.
Specimens examined: UNSW 14183 (Weeney Bay), 15049 (Careel Bay), 15071 (Port Stephens), 15088 (Middle Cove), 15246 (Pambula)
Remarks: Sphacelaria was recorded at six localities but in each case plants were small and infertile. No plants bore vegetative propagules.

Genus *Striaria* Greville 1828

Striaria attenuata Greville 1828: 44
References: Kornmann and Sahling, 1978: 280, fig. 161; Skinner and Womersley, 1983: 60, fig. 1(A), 2(A-F)
Type locality: Isle of Bute, Scotland
Reported distribution: North Atlantic and Mediterranean, New Zealand, southern Australia
Specimen examined: UNSW 15243 (Pambula)
Remarks: This species has hitherto been recorded from only two localities in Australia: Westlakes (Port Adelaide), South Australia, and Southport, Tasmania (Skinner and

Womersley, 1983). In this survey *S. attenuata* was found at only one locality on the NSW coast, Mangrove Island, just south of Pambula. Large plants (up to 40cm in length) occurred commonly in tangled masses amongst the pneumatophores and embedded in sand on the outer edge of the mangroves. The material collected fitted the description of the species given by Skinner and Womersley, 1983, except for the generally larger size of the plants at Pambula (Skinner, pers. comm.).

Division CHLOROPHYTA

Genus *Chaetomorpha* Kuetzing 1845

Chaetomorpha capillaris (Kuetzing) Boergesen 1925: 45, fig. 13
References: Womersley, 1956: 256; 1984: 178, figs 56C, 57E,F
Type locality: Nice, France
Reported distribution: Mediterranean Sea and Atlantic Ocean, southern Australia
Specimens examined: UNSW 15045 (Careel Bay), 15092 (Middle Cove)
Remarks: This species has previously been recorded in salt marsh and mangrove vegetation from Westernport, Victoria (Davey and Woelkerling, 1980), Spencer Gulf, South Australia (Beanland and Woelkerling, 1982) and Queensland (Saenger *et al.*, 1977). In this survey *C. capillaris* was recorded at four localities in the Sydney region. It occurred entangled on pneumatophores and as mats on mud surfaces amongst pneumatophores.

Genus *Cladophora* Kuetzing 1843

Cladophora coelothrix Kuetzing 1843: 272
Reference: Womersley, 1984: 190, figs 60C, 61C,D
Type locality: Livorno, Italy
Reported distribution: Fremantle, Western Australia to Moreton Bay, Queensland. Otherwise widespread
Specimen examined: UNSW 15015 (Tweed Heads)
Remarks: C. coelothrix was recorded at Tweed Heads where it occurred on *Avicennia* pneumatophores in sun-exposed areas.

Cladophora sp.
Specimens examined: UNSW 15048 (Careel Bay), 15074 (Port Stephens), 15234 (Batemans Bay)
Remarks: Plants of *Cladophora* were found attached to pneumatophores at a large number of localities. Specimens were small (mostly less than 1cm) and too young to identify with certainty.

Genus *Enteromorpha* Link 1820

Enteromorpha intestinalis (Linnaeus) Link 1820
References: Bliding, 1963: 139; Kornmann and Sahling, 1978: 78, fig. 37; Christianson *et al.*, 1981: pl. 148; Womersley, 1956: 353; 1984: 161, figs 50D, 51G,H
Type locality: Uncertain
Reported distribution: Cosmopolitan?
Specimens examined: UNSW 15046, 15203 (Careel Bay), 15204 (Middle Cove), 15220 (Minnamurra R.)
Remarks: Small plants, referable to *E. intestinalis*, were recorded for Middle Cove, Careel Bay and the Minnamurra R. Many of the small plants of *Enteromorpha* not identified to species level may belong to this taxon.

Enteromorpha prolifera (Mueller) J. Agardh 1883: 129
References: Bliding, 1963: 45, figs 19-29; Kornmann and Sahling, 1978: 71, pl. 32; Womersley, 1956: 353; 1984: 156, figs 48D, 49H
Type locality: Lolland, Denmark
Reported distribution: Widespread in temperate seas
Specimen examined: UNSW 15060 (Port Stephens)
Remarks: Material referable to *E. prolifera* was recorded only for Port Stephens.

Enteromorpha sp.
Remarks: Enteromorpha plants occurred on pneumatophores and other solid substrata at a number of localities. Most plants were small (less than 1cm) and none could be identified to species with certainty.

Genus *Percursaria* Bory 1828

Percursaria percursa (C. Agardh) Rosenvinge 1893: 963
References: Abbott and Hollenberg, 1976: 70, fig. 22; Bliding, 1963: 20, figs 5-6; Kornmann and Sahling, 1978: 62, fig. 27; Womersley, 1984: 135, figs 42A, 43A,B
Type locality: Hofmansgave, Denmark
Reported distribution: Widespread, on both tropical and temperate sheltered coasts
Specimens examined: UNSW 14172 (Sussex Inlet), 15059 (Port Stephens), 15084 (Tuncurry), 15247 (Pambula), 16264 (Towra Pt, Botany Bay)
Remarks: P. percursa has been recorded for a number of salt marsh and mangrove localities in south-eastern Australia (Womersley, 1984). In this survey it was found at a number of sites as far north as Tuncurry. Since it generally occurs only at the landward margin of the mangal on the sandy or muddy substrate, it is either not recorded or underrepresented in the frequency data. At some localities (e.g. Sussex Inlet) it was abundant with skein-like masses draped over pneumatophores and completely covering the substratum. In Botany Bay it occurred as floating masses in shallow salt marsh pools.

Genus *Rhizoclonium* Kuetzing 1843

Rhizoclonium implexum (Dillwyn) Kuetzing 1845: 206
References: Abbott and Hollenberg, 1976: 92, fig. 45; Womersley, 1984: 167, fig. 53A
Type locality: Bantry, Eire
Reported distribution: Cosmopolitan
Specimens examined: UNSW 15009 (Tweed Heads), 15096 (Middle Cove), 15201 (Careel Bay), 15226 (Minnamurra R.), 15230, 15235 (Batemans Bay)
Remarks: R. implexum often occurred mixed with other algae especially *Percursaria percursa* on mud surfaces in the landward portion of the mangal. The plants agree well with the concept of *R. implexum* in Abbott and Hollenberg (1976). The species has been recorded in the mangroves of Spencer Gulf, South Australia (Beanland and Woelkerling, 1982) and also for Queensland (Saenger *et al.*, 1977; Cribb, 1979).

Rhizoclonium riparium (Roth) Harvey 1849: pl. 239
References: Abbott and Hollenberg, 1976: 92, fig. 46, pl. 1, fig. 9; Kornmann and Sahling, 1978: 47, pl. 18A-F; Womersley, 1956: 361; 1984: 170, fig. 53D
Type locality: Norderney, Germany
Reported distribution: Cosmopolitan
Specimens examined: UNSW 13892 (lower Manning R.), 15002 (Stuarts Point)
Remarks: R. riparium was recorded at only two localities (lower Manning R. and Stuarts Point). Both these localities were hyposaline (18‰ and 23‰ respectively). *R. riparium*

occurred on the landward edge of the mangal either directly on the sandy substrate (Stuarts Point) or on logs and stones (lower Manning R.). The plants agree with the description of Californian plants (Abbott and Hollenberg, 1976) though only plants from lower Manning R. possessed the short rhizoidal branches generally regarded as characteristic of the species (Kornmann and Sahling, 1978). *R. riparium* was common in Victorian mangrove communities (Davey and Woelkerling, 1980) and in Spencer Gulf, South Australia (Beanland and Woelkerling, 1982). In the latter case the authors noted that rhizoidal branches were rare. Womersley (1984) regarded the range of filament diameters in the material of Beanland and Woelkerling to be too great.

Family Udoteaceae
(Genus *?Pseudochlorodesmis*)

?Pseudochlorodesmis sp.
Specimens examined: UNSW 15007 (Tweed Heads), 15029 (Hastings Point)
Remarks: This species formed a thick growth around pneumatophores of *Avicennia*, accreting mud to form a spongy cone-shaped collar around the pneumatophores. It occurred most commonly at the seaward edge of the mangrove vegetation.

Genus *Ulvaria* Ruprecht 1851

Ulvaria oxysperma (Kuetzing) Bliding 1968: 585, figs 31-34
References: Womersley, 1971: 113, fig. 1; 1984: 136, figs 42B, 43C,D; Abbott and Hollenberg, 1976: 68, fig. 19 as *Monostroma oxyspermum* (Kuetzing) Doty
Synonym: Monostroma oxyspermum (Kuetzing) Doty
Type locality: Baltic Sea, Germany
Reported distribution: Widespread in temperate regions
Specimens examined: UNSW 13884 (Mill Ck head), 13889 (Harrington), 15005 (Stuarts Point), 15018 (Ballina), 15032 (Hastings Point), 15039 (Port Macquarie), 15044 (Careel Bay), 15058 (Port Stephens), 15083 (Tuncurry), 15093 (Middle Cove), 15201 (Georges Hall), 15222 (Minnamurra R.), 15248 (Pambula)
Remarks: This species was not recorded for the mangrove communities of either Victoria (Davey and Woelkerling, 1980) or Spencer Gulf, South Australia (Beanland and Woelkerling, 1982). Womersley (1984) recorded it as widespread, in winter, in calm waters, bays and inlets in southern Australia and north to Botany Bay, NSW. It was present at almost all sites on pneumatophores and especially on other solid substrata (wood, stones and decaying leaves and twigs of terrestrial vegetation). It appeared to be more abundant in the more sun-exposed positions of the seaward and landward edges of the mangrove vegetation. Cribb (1979) recorded *Monostroma ?oxyspermum* for Moreton Bay, Queensland.

Frequency Data

Frequency data for the taxa collected at all sites, are summarized in Table 2. Table 2 also records presence of species not epiphytic on pneumatophores. Nine taxa occurred commonly (percentage frequency, F = 50-75%) or abundantly (F > 75%) at one or more localities: *Bostrychia flagellifera, B. moritziana, B. simpliciuscula, Caloglossa leprieurii, C. ogasawaraensis, Catenella nipae, Chaetomorpha capillaris, ?Pseudochlorodesmis,* and *Ulvaria oxysperma*. Based on the mean frequency values (i.e. $\bar{F}$ = F/N where F is the sum of all recorded frequencies greater than zero and N the total number of localities at which the alga occurred) *Caloglossa leprieurii* is the most frequently occurring alga (F = 57), followed by *Bostrychia flagellifera* (F = 55). *Catenella nipae* was the most widespread species, occurring at all localities except the hyposaline site at Georges Hall. Five other species,

TABLE 2

Percentage frequency data for algae associated with New South Wales mangroves
(Taxa found outside sampling transects or not growing epiphytically on pneumatophores are recorded as present — P).

SITES	Tweed Heads	Hastings Point	Ballina	Stuarts Point	Port Macquarie	Harrington	lower Manning R.	Tuncurry	Port Stephens	Fullerton Cove	Careel Bay	Middle Cove	Weeney Bay	Mill Ck head	Mill Ck mouth	Georges Hall	Minnamurra R.	Sussex Inlet	Batemans Bay	Bermagui	Pambula	Mean % Frequency
No. of pneumatophores sampled	40	40	40	40	40	40	20	40	40	40	40	40	40	20	20	40	40	100	40	40	40	
TAXON																						
RHODOPHYTA																						
Bostrychia flagellifera	48	60	P	75	15	P	85		53	58	3	P	P		100		P	P				55
B. intricata			P	P														P			P	
B. kelanensis	P																					
B. moritziana	63		43	25	68	3	35	25	65	23	60	25	45	95		68	10	2		28	20	39
B. simpliciuscula	90	53	18	45	8			8	13	15		20	48		20		20	P		8	50	31
Caloglossa adnata			33																			33
C. leprieurii	55	60	58	40	75	23	70	45	53	75	58	38	75	95	95	P	30	3		55	78	57
C. ogasawaraensis	13	P	25		23	P	5		90		58	23	3			25						29
Catenella nipae	3	8	45	13	90	P	5	5	40	55	58	23	45	P	50		30	2	P	15	53	32
Centroceras clavulatum									15													15
Chondria sp.									43													43
Erythrotrichia carnea			3																			3
Gracilaria verrucosa	5	18	10		5		5				3	P	5								3	7
Polysiphonia ?scopulorum								P	P		P	P										
Spyridia filamentosa								3	8		P		P									6
PHAEOPHYTA																						
Acinetospora crinita											10											10
Asperococcus bullosus									P				P							P		
Ectocarpus siliculosus				P												P			P	P	P	
Hormosira banksii													P							P	13	13
Sphacelaria sp(p).									33		13	38	P			3				3	33	21
Striaria attenuata																					P	
CHLOROPHYTA																						
Chaetomorpha capillaris											5	18	P	60								28
Cladophora coelothrix	8																					8
Cladophora sp.		3	20			13			18		3		P	10			23		P	3	23	13
Enteromorpha intestinalis											P	5					10					8
E. prolifera								P														
Enteromorpha sp.	3					8		5	5		13			30		8			28	13	28	14
Percursaria percursa								P	P			3	P					P			3	3
Rhizoclonium implexum	5	3		P	3	13		13	3	3	P	15	13	5			P	2	P	38	30	11
R. riparium				P			20															20
?Pseudochlorodesmis	50	38																				44
Ulvaria oxysperma		P	10	P	P	15		3	P		10	3		50		P	18	7	5	63	70	23

Bostrychia flagellifera, B. moritziana, B. simpliciuscula, Caloglossa leprieurii and *Ulvaria oxysperma* occurred at more than 75% of localities.

Discussion

The marine flora of southern Australia is rich and diverse with over 1100 species of macroalgae recorded (Womersley, 1981). The marine botany of the NSW coast is less well known, and although there are many distinctive and endemic floral elements (Allender and Kraft, 1983) it has been accepted generally that the flora is not as rich as its southern counterpart. This is due to the fact that many of the cool-temperate elements, and in particular many of the endemic southern species in the Fucales, Caulerpales, and the Rhodophyta generally, do not extend to NSW, and the relatively few more tropical species do not compensate for this loss.

In comparison with the flora of adjacent rocky coasts, the algal flora of mangrove habitats is generally depauperate. In Victoria only 23 species of algae (13 Rhodophyta, 3 Phaeophyta, 6 Chlorophyta, 1 Chrysophyta) have been recorded (Davey and Woelkerling, 1980) and for Spencer Gulf, South Australia 49 species (28 Rhodophyta, 9 Phaeophyta, 10 Chlorophyta, 2 cyanobacteria), (Beanland and Woelkerling, 1982). King (1981a) listed 18 species of macroalgae (13 Rhodophyta, 2 Phaeophyta, 2 Chlorophyta, 1 Xanthophyta) for salt marsh and mangrove habitats in NSW, while the present more detailed study reports 32 taxa (15 Rhodophyta, 6 Phaeophyta, 11 Chlorophyta) for mangrove habitats only.

When making direct comparisons between such species numbers provided by different authors, some caution is necessary.

The criteria used to assign a particular alga to the mangrove habitat are rarely the same in each study. Many algae washed in from adjacent rocky coasts or seagrass beds can survive, unattached, in the mangrove habitat for variable lengths of time. Since many of the mangrove algae also occur in adjacent communities (rocky coast and seagrass beds), it is sometimes unclear whether some plants recorded should be properly regarded as part of the mangrove system. In his study in Moreton Bay, Cribb (1979) included essentially subaerial species such as *Pseudendoclonium submarinum* and two species of *Trentepohlia* from the trunks of the mangrove trees. *Trentepohlia* was common on mangrove trunks at most sites along the NSW coast, but was not included in the present study.

Seasonal factors affect the number of species recorded and this is particularly relevant when surveys are carried out over a limited part of the year, e.g. Davey and Woelkerling, 1980, March-September; Beanland and Woelkerling, 1982, March-July. The present study was undertaken during July-October, 1983.

The degree to which the species collected at any site represents the total algal flora must also be considered. The use of transects and general collections in the vicinity of the transects does not guarantee that all the species present at a site will be collected. For example, it would have been easy to have failed to record *Caloglossa adnata* at Ballina, since it appeared to have a localized distribution in areas of dense shade within the widespread and well developed mangrove vegetation in the area. Species such as the mangrove form of *Hormosira banksii*, have very limited distributions, but where they are found they occur in abundance. Unattached *H. banksii* populations are reported only for southern Botany Bay (King, 1981a,b,c) and Carama Inlet (Jervis Bay) on the NSW coast but at both localities the distribution is very limited in extent.

Direct comparisons of species lists are made particularly difficult when taxa are not fully identified.

For these reasons the species lists available for various parts of the Australian coast cannot be readily compared.

Of the 18 taxa that King (1981a) listed for NSW, eight were not recorded in the present study, while an additional 22 species were recorded. The eight taxa previously recorded for NSW but not found in this survey are:

Bostrychia binderi. Post (1963) recorded *B. binderi* south to Sydney on the basis of a specimen collected by Grunow (December 1884) at the mouth of the Parramatta River. There are no more recent records.

Bostrychia radicans. Until the relationship between *B. radicans* and *B. simpliciuscula* is clarified we have referred all our material to the latter species.

Bostrychia tenella was recorded for NSW, but until authenticated specimens are available this record should be regarded with suspicion. The species is recorded by Cribb (1979) for Moreton Bay and Saenger *et al.* (1977) for Gladstone, Queensland.

Ceramium was not recorded in this survey, although the genus is generally common on NSW coasts.

Gracilaria edulis was recorded for NSW by Saenger *et al.* (1977), as *G. lichenoides*. This species is widely distributed in estuarine localities in NSW (May 1948) but until its presence and true status within mangrove systems is elucidated, it should be excluded from the NSW list.

Dictyota dichotoma is probably best considered not part of the characteristic mangrove algal community. If it is included then it would be proper to include species of *Colpomenia, Microdictyon, Codium* and *Sargassum*, all of which continue growth in the mangal as cast plants.

Ulva lactuca was not recorded at any locality in this survey, although *Ulva* does occasionally occur on pneumatophores at least in Botany Bay.

Vaucheria sp. was recorded by King (1981a) but it appears to be confined to the salt marsh.

None of the species recorded in this survey is endemic to NSW, which reflects both the cosmopolitan nature of mangrove-associated algae and the fact that NSW represents a transition between temperate and tropical climatic regimes. Some of the species are widely distributed in NSW mangroves, as well as in the mangroves of Spencer Gulf (South Australia), Victoria, Queensland and extra-Australia. These include *Bostrychia moritziana, B. simpliciuscula, Caloglossa leprieurii, Ectocarpus siliculosus* and *Rhizoclonium implexum. Catenella nipae* and *Ulvaria oxysperma* have similarly broad distributions, although *C. nipae* was not found in South Australia, and *U. oxysperma* has not been recorded in mangals in either Spencer Gulf or Victoria. *Ulvaria* does however occur in southern Australia in estuarine localities (Womersley, 1984). The absence of *Ectocarpus siliculosus, Rhizoclonium implexum* and *Ulvaria oxysperma* from previous NSW taxonomic lists reflects the limited work carried out on mangrove habitats in this state. *Spyridia filamentosa* is similarly widespread (though not reported for Victoria), and its absence from many sites in NSW may be attributed to seasonal occurrence. In Botany Bay it has been abundant in September but at other times apparently absent.

A few of the algal species recorded are of tropical affinity and extend varying distances south into NSW. New records for *Bostrychia kelanensis* and *Caloglossa adnata* extend their known distributions to Tweed Heads and Ballina respectively. The sub-tropical *Bostrychia flagellifera* extends south to Nelson Lagoon but is only abundant in northern localities. Some species of cool-temperate affinities extend northwards into NSW. New records for *Percursaria percursa* extend its known distribution north to Tuncurry. The range of *Asperococcus bullosus* has been extended from Pittwater north to Port Stephens.

This species is initially epiphytic on *Posidonia* leaves in the sublittoral and it is therefore not strictly a mangrove alga.

Apart from those species with tropical and cool-temperate affinities and those that are widespread on the NSW coast, there are other species of limited distribution. In some cases such discrete distributions seem to be related to characteristics of the particular collection site. Thus *Centroceras clavulatum* and *Chondria* sp., which normally occur on rocky coasts in NSW, were recorded as epiphytes on pneumatophores only at Port Stephens. This may be explained by the open marine nature of this particular site, which also had a sandy substrate. The distribution of *Erythrotrichia carnea* is probably wider than the single record at Ballina indicates, as the small size of the plants makes them easily overlooked in broad scale survey. *Bostrychia intricata* was previously recorded for Sydney (Kirribilli, Port Jackson) by Post (1936). In this survey it was never abundant in mangroves but occurred sporadically throughout the state. It is recorded, however, for Victoria, South Australia and Queensland. The sole NSW record of *Striaria attenuata* at Pambula represents a significant extension of its reported distribution. *Acinetospora crinita* was recorded only from Careel Bay where it formed tangled masses amongst pneumatophores at the seaward edge of the mangrove zone.

TABLE 3

Comparison of the distribution of macroalgae

Based on species of algae recorded from mangrove ecosystems in Queensland, NSW, Victoria and South Australia. The number of species for each algal Division is given along with the percentage of species common to NSW. Taxa not identified to species level are excluded from this comparison as are all cyanobacteria, Xanthophyta and Chrysophyta, a number of microscopic green algae reported by Cribb (1979) for Moreton Bay *(Apatococcus lobatus, Pseudendoclonium submarinum, Trentepohlia odorata, T. rigidula)* and cast plants found in mangrove communities but which were originally growing on nearby rocky shores and/or adjacent sublittoral seagrass beds (e.g. *Gracilaria edulis, Asperococcus bullosus, Colpomenia sinuosa, Dictyota dichotoma*). (Reference sources are numerically coded.)

	NSW (1,2)	QLD (3,4)	VIC (5)	SA (Spencer Gulf)(6)
RHODOPHYTA	15	25 (87%)	12 (47%)	28 (40%)
PHAEOPHYTA	4	2 (25%)	2 (25%)	7 (50%)
CHLOROPHYTA	10	8 (30%)	4 (30%)	8 (50%)
TOTAL	29	35 (59%)	18 (38%)	43 (45%)

Reference code: 1, Present study; 2, King (1981a); 3, Cribb (1979); 4, Saenger *et al.* (1977); 5, Davey and Woelkerling (1980); 6, Beanland and Woelkerling (1982).

A comparison with the number of species in other states is given in Table 3. It is surprising that only 18 species of mangrove-associated algae are recorded for Victoria given the large diversity of open coast species in that state. In Victoria however, mangroves reach their southernmost limit and communities are not well developed. Also they occur over a limited latitudinal range. The total number of species recorded in Spencer Gulf, South Australia, is enhanced by five coralline algae (O. Cryptonemiales, F. Corallinaceae) and three species of *Audouinella* (O. Nemalionales, F. Acrochaetiaceae) (Beanland and Woelkerling, 1982).

Overall, the NSW mangrove algal flora has greatest similarity with that of Queensland: 59% of the NSW species are also found in Queensland, compared with only 38%

in Victoria and 45% in South Australia. The percentage of species shared with Queensland is highest in the Rhodophyta (87%). This is due to those algae regarded as characteristic of the mangrove habitat, the so-called '*Bostrychia-Caloglossa* Association' being essentially the same in both states. The low species numbers in both the Phaeophyta and Chlorophyta reported in Australian mangrove ecosystems means that comparisons for these Divisions have little value, especially so since almost all of the species are more generally found on nearby rocky shores.

The frequency data are based only on algae collected on pneumatophores of *Avicennia marina*. Given the limited sampling strategy adopted in this broad scale survey the data have limited statistical significance. Pneumatophores provide one of the few stable substrata for the attachment of epiphytic algae in the mangrove habitat. In mangrove communities dominated by *Avicennia* the pneumatophores allow for rapid collection of data. While pneumatophores provide the substratum for the characteristic '*Bostrychia-Caloglossa* Association', other algae, especially in the Divisions Chlorophyta and Phaeophyta, have members which grow directly on the mud or sand surfaces, either amongst the pneumatophores or behind the mangroves and extending into the saltmarsh vegetation. Such species include *Ectocarpus siliculosus, Hormosira banksii, Striaria attenuata* (Phaeophyta) and *Rhizoclonium implexum, R. riparium, Chaetomorpha capillaris, Percursaria percursa* and *Ulvaria oxysperma* (Chlorophyta). This limits the value of collections and statistical data resulting only from collections on pneumatophores. Furthermore where the substratum is sandy or gravelly, and presumably more aerated, *Avicennia* produces fewer pneumatophores (as for example at Batemans Bay and Pambula), and in these situations the characteristic mangrove algae are much less common, and free floating forms or forms that grow directly on the mud or sand substratum are comparatively well represented.

Avicennia is the dominant mangrove tree species on the NSW coast, and the only one that produces pneumatophores. *Aegiceras corniculatum*, which occurs in association with *Avicennia* at most of the sites studied, sometimes forms almost pure stands. In such localities it is impossible to collect frequency data as outlined in this report. In northern NSW other mangrove species occur which produce either different root modifications on which algae can grow (the silt roots of *Rhizophora stylosa* and the knee roots of *Bruguiera gymnorhiza*) or no root modifications at all *(Excoecaria agallocha* and *Hibiscus tiliaceus)*. The latter two species occur only at the most landward margin of the mangal. These other mangrove species reduce the density of *Avicennia marina* especially at upper levels, as well as providing alternative substrata on which algae can grow. Since the frequency data are based on the algae on the five pneumatophores nearest the transect point, this does not necessarily bias the collection. In no case were there no *Avicennia* pneumatophores within 50cm of the transect point.

The most frequently occurring and widely distributed algae were those of the *Bostrychia, Caloglossa, Catenella* group, along with *Ulvaria oxysperma. Caloglossa leprieurii* occurred with the highest frequency (percentage mean frequency, 57% as it also did in Victoria, at 69% (Davey and Woelkerling, 1980) and Spencer Gulf, 50% (Beanland and Woelkerling, 1982). Comparison of the number of species present at any particular locality (Table 2) reveals wide variation. Long term salinity data are not available but there does appear to be a considerable reduction in the number of species present in the hyposaline localities at lower Manning River, Mill Creek and Georges Hall. At other localities, e.g. Batemans Bay, some other factor(s) must play a role. There, and at Sussex Inlet, the pneumatophores are relatively free of epiphytic algae, the frequency of all algae being 5 and 16 respectively. Corresponding figures for Tweed Heads and Port Macquarie are 301 and 334.

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